Gradients of the Lorentz factor in orthogonal metrics of the relativistic dust sphere

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Abstract

It is shown that during the rotation of relativistic objects with a radius of up to 300 km, the Lorentz factors can have intermittent and discrete properties. The possibility of the coexistence of objects with significantly different local time flows at accessible distances is discussed - a phenomenon that has not been considered before even in science fiction literature.

In my work [5], it is shown that the vertical change in the metric in the direction of the rotation axis z of a massless sphere at c = 1 is equal to:

$$\frac{dz}{dw}=\frac{\sqrt{3}}{2\omega^2}\ln\left(1-r^2\omega^2\sin^2\theta\right)+\frac{\sqrt{3}r^2\omega\sin^2\theta}{1-r^2\omega^2\sin^2\theta}$$

The dimension "meter × second (m x s)" can be interpreted in this case as the rate of change of the metric in the context of geometric representations of space-time.

However, it is possible to represent the change in the metric as a physical velocity. When a sphere rotates with acceleration α, the angular velocity is equal to:

$$\omega=\omega_0+\alpha*t$$

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Then the speed of the metric at the equator ($\mathcal{Q}$ =π/2) in the direction parallel to the z axis:

$$v_z = \frac{dz}{dw}\frac{dw}{dt} = \frac{\sqrt{3}c\alpha}{2(\omega_0+\alpha t)^2}(\ln\left(1-\frac{x^2(\omega_0+\alpha t)^2}{c^2}\right)+\frac{\sqrt{3}c\alpha r^2(\omega_0+\alpha t)}{(c^2-r^2(\omega_0+\alpha t)^2)}) \qquad (1)$$

At c =1:

$$v_z = \alpha(\frac{\sqrt{3}}{2\omega^2}\ln(1-r^2\omega^2)+\frac{\sqrt{3}r^2\omega}{1-r^2\omega^2}) \qquad (2)$$

Tangential speed: $v_x = v_y = \omega * r$

Substituting the tangential speed into the vertical one, we obtain the dependence of orthogonal speeds:

$$v_z = \alpha(\frac{\sqrt{3}}{2\omega^2}\ln(1-v_x^2)+\frac{\sqrt{3}r v_x}{1-v_x^2}) \qquad (3)$$

or after transformation:

$$v_z = \alpha\frac{\sqrt{3}}{2\omega^2}(\ln(1-v_x^2)+\frac{2v_x\omega^2}{1-v_x^2}) \qquad (4)$$

Now it is easy to find the Lorentz factors. And although the speeds in two different directions are dependent, and , therefore, are dependent Lorentz factors - metrics remain independent. They are orthogonal, represent the geometry of space, and not material objects.
Let us note as an additional explanation that, for example, according to the authors of [1,2,3], the possibility of superluminal expansion of space-time in cosmology does not contradict the special theory of relativity, since we are talking not about the movement of matter, but

about the expansion of space itself. For example, in inflationary models of the Universe, distances between points can increase faster than the speed of light.
This does not violate causality if we are talking about the expansion of space, and not about the movement of information or matter. However, in this article, the inflationary model is not considered.

Lorentz factor for horizontal and vertical directions:

$$\tau_x(t)=\frac{1}{\sqrt{1-v_x^2}} \qquad \tau_z(t)=\frac{1}{\sqrt{1-v_z^2}} \tag{5}$$

As we can see (Fig. 1 and 2), time flows differently in orthogonal directions, which means that we are dealing with an anisotropic space-time continuum. The proposed model presents two components: horizontal (τ_x) and vertical (τ_z). When these components become equal at certain parameter values, a special region appears in the evolution of the system where anisotropy disappears.
The fact that such a configuration is possible only with a single set of parameters suggests that this is a certain "critical point" of the system, where anisotropy can be observed special phase transitions and the energy state of the system.
When time flows at noticeably different rates in orthogonal directions at close distances, one cannot help but consider the theoretical possibility of some form of "time travel" or, more precisely, some speculative manipulation of the flow of time.
Here are some theoretical possibilities. Differential aging: by moving along certain trajectories in such a space, an object can "accumulate" its own time at different rates. This is not classical "time travel", but allows one observer to experience more or less of its own time than another.
Closed timelike curves: in spaces with sufficiently complex geometry, anisotropy can lead to the formation of closed timelike curves, which theoretically allow one to return to the past. This occurs when the

difference in the rate of time flow is so great that it creates "loops" in space-time. At points where the gradient of the rate of time flow is especially large, it is possible to create local conditions for slowing down or speeding up the flow of time relative to an external observer. Areas where time flows significantly more slowly can serve as a kind of "time pockets", allowing objects inside them to exist as if "outside the time" of the external world.
A model where т_x = т_z can be a transition point between different modes of time flow. Theoretically, carefully planned movement through such points and the use of differences in the rate of time flow could create conditions for effective "movement" in time relative to an external observer.
Of course, all this remains at the level of theoretical speculation, and the implementation of such effects would require control over gravity and space-time, significantly exceeding modern technological capabilities. But one cannot exclude the possibility of involuntary, random similar travels for some particles or larger material objects, especially if there are gradients of the flow of time in these local areas of space.
And they do.
Let us differentiate the Lorentz factor in the horizontal direction, by:

$$\frac{d\tau_x}{dt}=\frac{1}{2}\left(1-v^2\right)^{-3/2}\cdot 2v\cdot\frac{dv}{dt} \qquad (6)$$

where (hereinafter everywhere x = r):

$$\frac{dv}{dt}=\alpha x$$

We simplify:

$$\frac{d\tau_x}{dt}=\frac{v\alpha x}{\left(1-v^2\right)^{3/2}} \qquad (7)$$

At $w0 = 0$, the first derivative of the Lorentz factor:

$$\frac{d\tau_x}{dt} = \frac{\alpha^2 x^2 t}{\left(1-(\alpha x t)^2\right)^{3/2}} \quad (8)$$

Here it is difficult to provide the derivation of the remaining formulas for the first and second derivatives of the Lorentz factors of the horizontal and vertical directions, they are cumbersome and therefore are defined numerically to the third or second approximations using the corresponding Python 3.12 program.
At points where the gradient of the rate of time flow is especially large, it is possible to create local conditions for slowing down or speeding up the flow of time relative to an external observer.

In a region with a high first-order gradient (first derivative $-\nabla\tau/\nabla t$, Fig. 3), a small displacement in space leads to a significant change in the rate of time flow. Here, significant tidal forces can arise due to the difference in the rate of time flow in different parts of an extended object
In a region with a high second-order gradient (second derivative $d^2\tau/dt^2$, Fig. 3), not only does the rate of time flow change rapidly, but the rate of change itself also undergoes rapid changes. This creates conditions for resonance phenomena, when the system can "swing" between different rates of time flow.
Below are the possible physical effects in such conditions.
At the moment of the appearance of the second derivative relativistic factor bursts, the radiation of electromagnetic waves (analogous to synchrotron or bremsstrahlung radiation) should be observed.
At the points where the curves intersect, both systems have identical acceleration dynamics, which allows for instantaneous "synchronization" of two different relativistic systems before one of them experiences a sharp jump.
Of particular interest is the discrete nature of the change in the first and second derivatives of the Lorentz factor for small relativistic objects with a radius of up to 300 km. (Fig. 4 and 5) Such objects require further study.

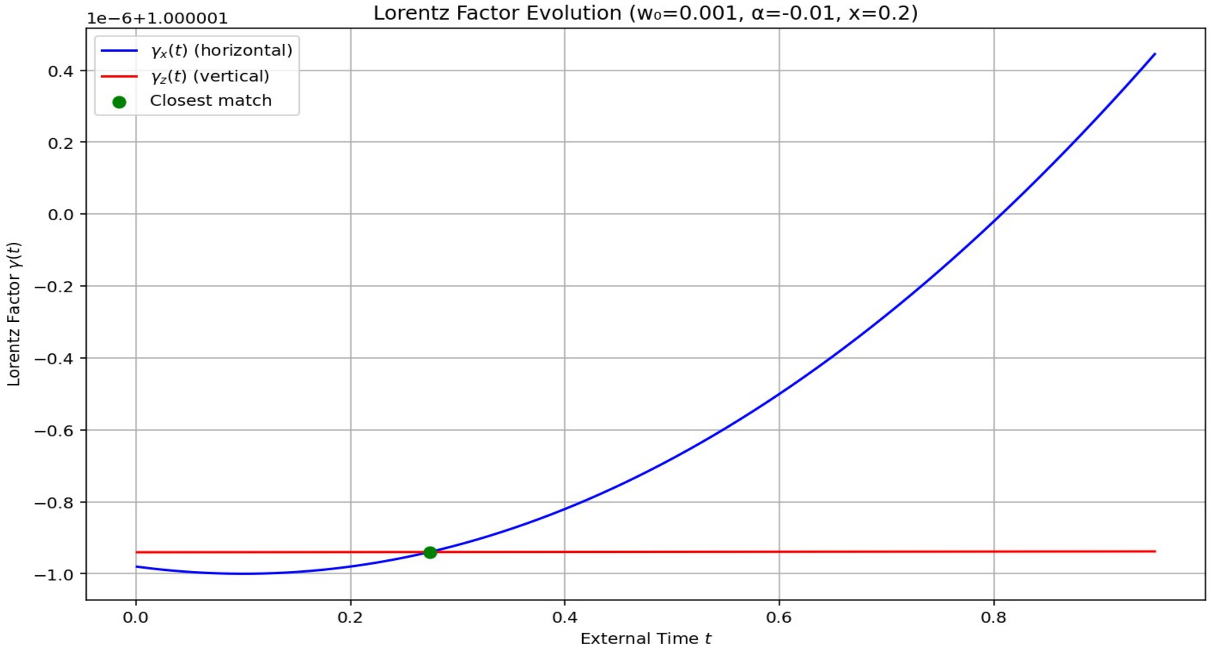

Lorentz Factor Evolution (w₀=0.001, α=-0.01, x=0.2)
1e−6+1.000001
$\gamma_x(t)$ (horizontal)
$\gamma_z(t)$ (vertical)
Closest match
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
Lorentz Factor $\gamma(t)$
0.0
0.2
0.4
0.6
0.8
External Time t

Fig.1

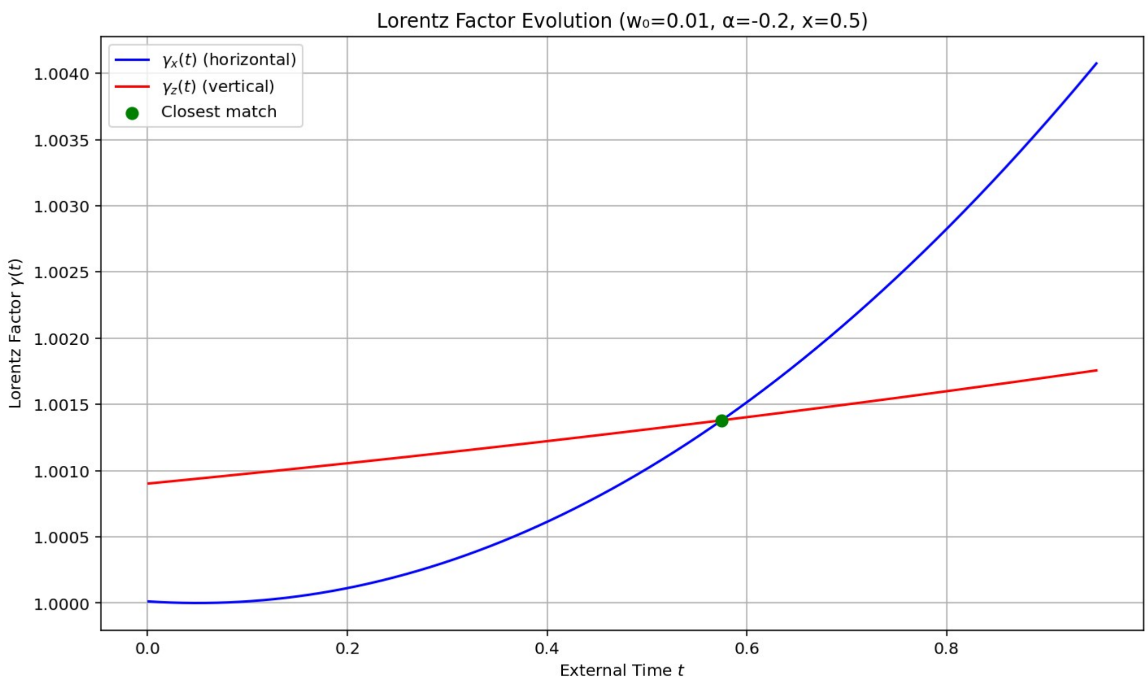

Lorentz Factor Evolution (w₀=0.01, α=-0.2, x=0.5)
$\gamma_x(t)$ (horizontal)
$\gamma_z(t)$ (vertical)
Closest match
1.0040
1.0035
1.0030
1.0025
1.0020
1.0015
1.0010
1.0005
1.0000
Lorentz Factor $\gamma(t)$
0.0
0.2
0.4
0.6
0.8
External Time t

Fig.2

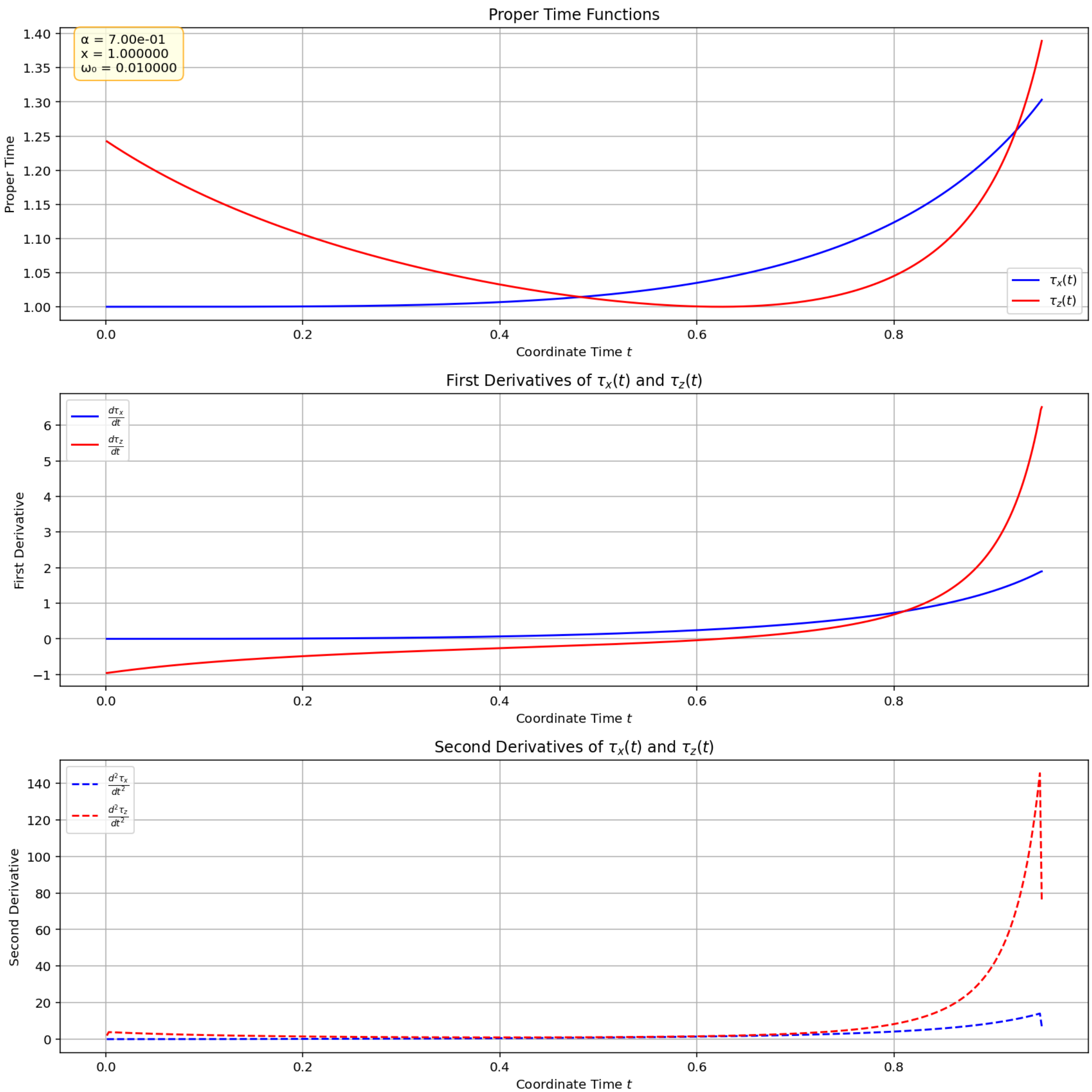
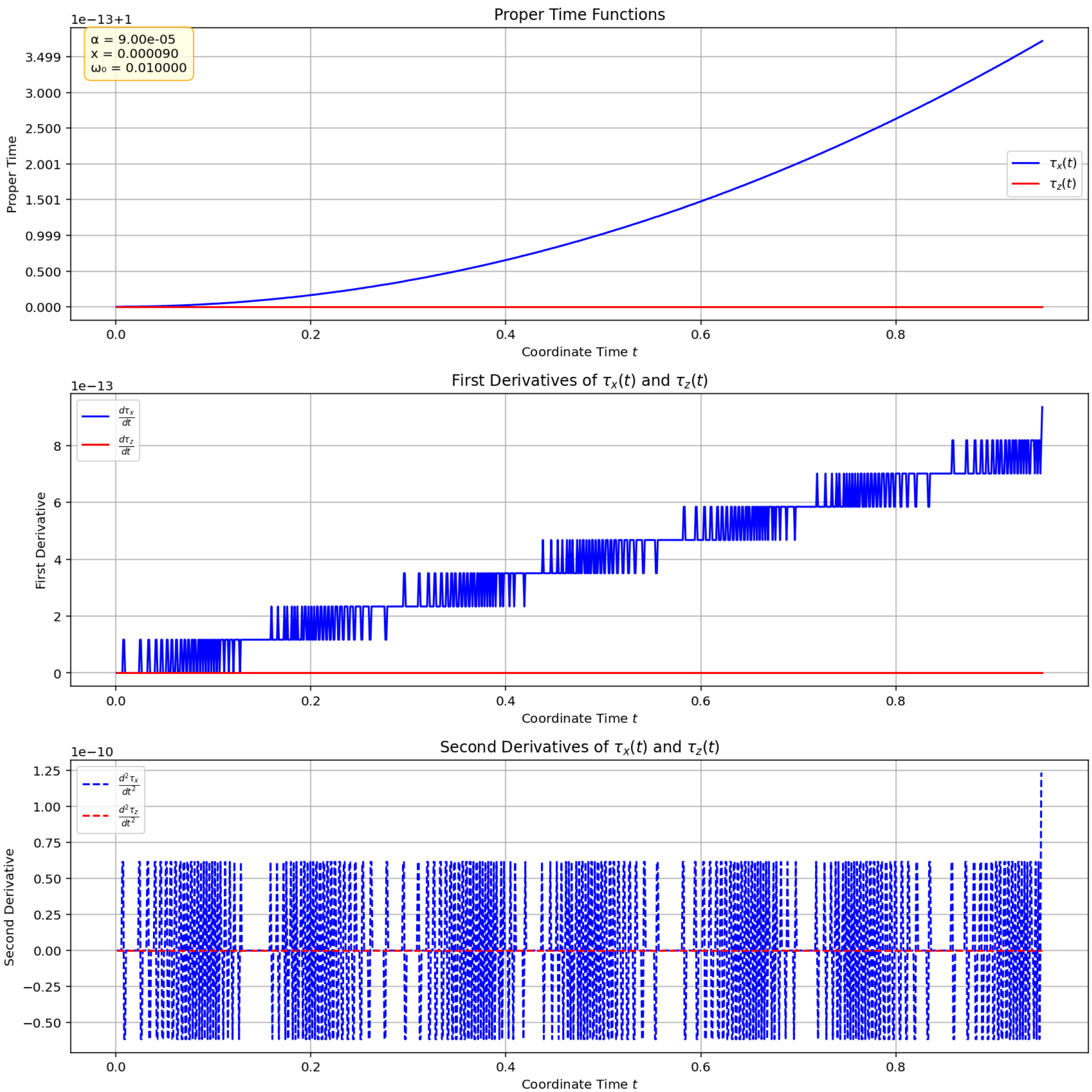

Proper Time Functions
α = 7.00e-01
x = 1.000000
ω₀ = 0.010000
Proper Time
Coordinate Time t
$\tau_x(t)$
$\tau_z(t)$
First Derivatives of $\tau_x(t)$ and $\tau_z(t)$
$\frac{d\tau_x}{dt}$
$\frac{d\tau_z}{dt}$
First Derivative
Coordinate Time t
Second Derivatives of $\tau_x(t)$ and $\tau_z(t)$
$\frac{d^2\tau_x}{dt^2}$
$\frac{d^2\tau_z}{dt^2}$
Second Derivative
Coordinate Time t

Fig.3



Proper Time Functions
1e−13+1
α = 9.00e-05
x = 0.000090
ω₀ = 0.010000
Proper Time
Coordinate Time t
τx(t)
τz(t)
First Derivatives of τx(t) and τz(t)
1e−13
First Derivative
dτx/dt
dτz/dt
Coordinate Time t
Second Derivatives of τx(t) and τz(t)
1e−10
Second Derivative
d²τx/dt²
d²τz/dt²
Coordinate Time t

Fig.4

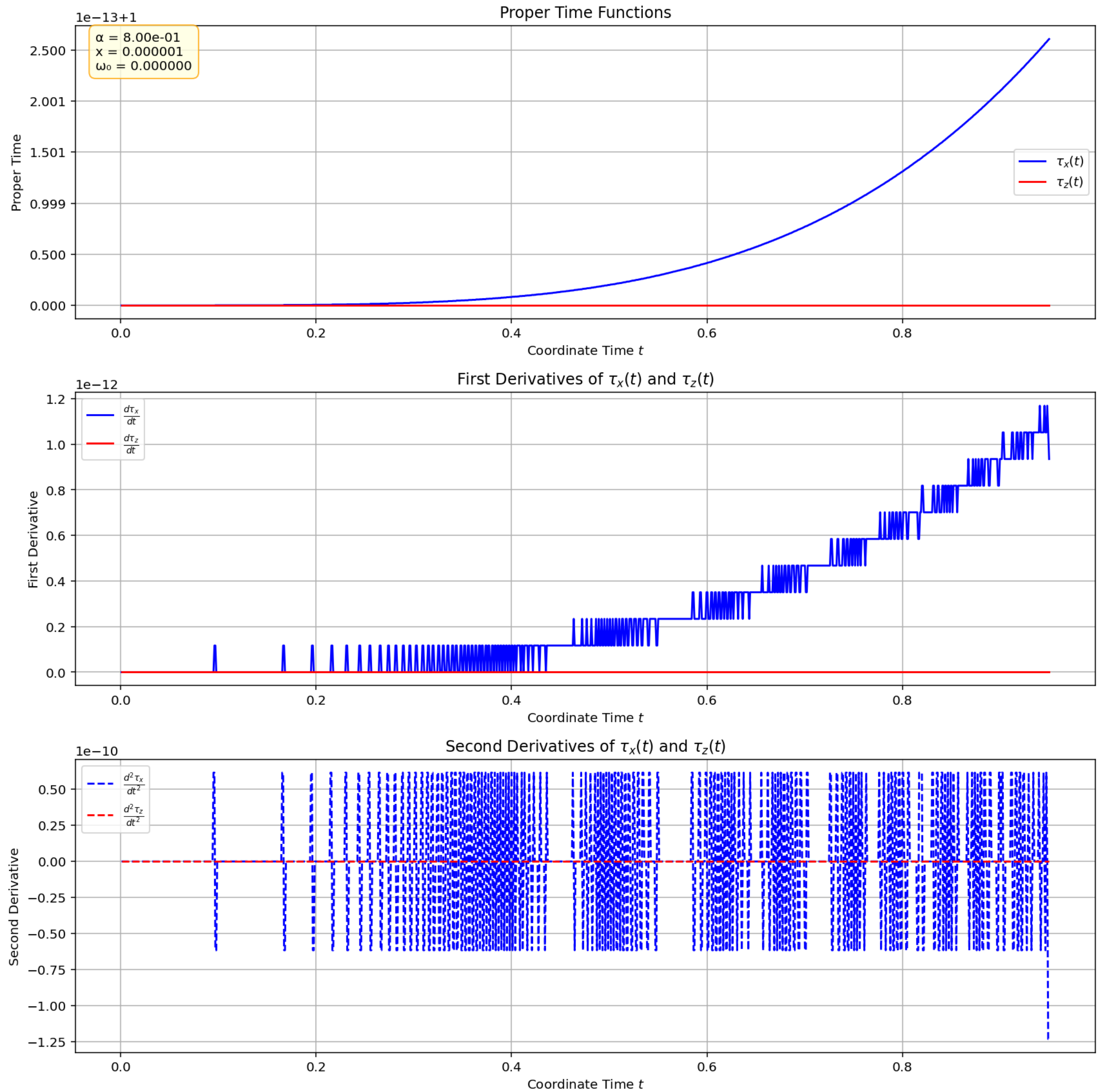

Proper Time Functions
1e−13+1
α = 8.00e-01
x = 0.000001
ω₀ = 0.000000
2.500
2.001
1.501
0.999
0.500
0.000
Proper Time
$\tau_x(t)$
$\tau_z(t)$
0.0
0.2
0.4
0.6
0.8
Coordinate Time t
First Derivatives of $\tau_x(t)$ and $\tau_z(t)$
1e−12
1.2
1.0
0.8
0.6
0.4
0.2
0.0
First Derivative
$\frac{d\tau_x}{dt}$
$\frac{d\tau_z}{dt}$
Coordinate Time t
Second Derivatives of $\tau_x(t)$ and $\tau_z(t)$
1e−10
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.25
Second Derivative
$\frac{d^2\tau_x}{dt^2}$
$\frac{d^2\tau_z}{dt^2}$
Coordinate Time t

Fig.5

Literature

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